



Screening Methodology for Calculating ANC Change to High Elevation Lakes

USDA Forest Service • Rocky Mountain Region
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Introduction

The purpose of this screening methodology is provide a simplistic step-by-step process that can be used in New Source Review and NEPA(National Environmental Policy Act) processes to predict air pollution caused changes to the chemistry of sensitive lakes. Like other air quality related value screening methodologies this relatively conservative approach can be used to determine if a proposed source or group of sources either do not have the potential to impact wilderness lakes or if it is appropriate to conduct a more complex but less conservative analysis.

This screening methodology uses a very simplistic set of equations to estimate how additions of sulfate and/or nitrate deposition from air pollution sources may cause a change in lake acid neutralizing capacity (ANC) from a monitored baseline. The methodology uses the following assumptions:

- * The generation of acid neutralizing capacity in the watershed catchment to be analyzed is constant over time.
- * All atmospheric deposition of sulfates and nitrates into the catchment enters the lake and neutralizes an equivalent amount of acid neutralizing capacity.
- * The monitored baseline acid neutralizing capacity of the lake represents baseline acid neutralizing capacity of all of the water in the catchment.

These assumptions are meant to be conservative and, as such, do not incorporate aquatic ecosystem biogeochemistry. However, the methodology is appropriate to produce a relatively low cost screening level estimate of potential change in acid neutralizing capacity caused by a single pollution source or group of sources.

This approach is based on previous research papers by Fox, 1983 and Clayton, 1998, with changes suggested by Jim Clayton (personal communication) and John Turk (personal communication). In complex situations or where the screening results exceed Forest Service Limits of Acceptable Change (thresholds of concern), a more sophisticated model such as the Model of Acidification of Groundwater in Catchments (MAGIC) should be run (Sullivan, 1995).

In order to assist in the use of this screening methodology the Forest Service will provide new source applicants or those persons conducting NEPA analysis with the following:

- (1) A list of lakes for which potential change in acid neutralizing capacity should be calculated in the wilderness areas of concern, along with map coordinates for those lakes. In most cases, only one or two lakes per wilderness will be identified for analysis.

(2) Baseline lake acid neutralizing capacity as determined by monitored chemistry at the lakes of concern. Baseline acid neutralizing capacity values will usually be for the most sensitive (10% lowest) acid neutralizing capacity values from the lake so that predicted lake chemistry changes will consider sensitive (low acid neutralizing capacity) conditions that may occur on an episodic or seasonal basis.

(3) Estimates of watershed catchment size.

(4) Estimates of the average annual precipitation amounts for the catchment area.

For each analysis, the screening methodology will usually be applied twice:

- * first to predict any change in acid neutralizing capacity from the proposed new source or proposed action by itself and,

- * second to predict any change in acid neutralizing capacity from the cumulative total of all emissions sources that are included in the cumulative impact analysis (where applicable).

Process

Step 1: Computation of Deposition Flux from Annual N and S Emissions

The purpose of the following conversions is to produce outputs in both kg/ha/yr for reporting deposition (to evaluate aquatic and terrestrial effects) and in eq/m²/yr to evaluate lake ANC change. Various models produce outputs in different formats. The following instructions will provide model outputs in the correct format to proceed with Step 2.

A.) **CALPUFF model output:** includes S from SO₂ and SO₄; and N from NO₂, HNO₃, and NO₃. Use the recommendations in IWAQM-Phase 2 (p 30-31) for calculation of N and S deposition in kg/ha/yr from the CALPUFF or CALPUFF-Screen modeling outputs. D_s will be the sum of all sulfur species and D_n will be the sum of all nitrogen species

OR

B) **ISCST or other approved model outputs:** some models may report all S outputs as SO₂ and all N outputs as NO₂. In this case, use the calculation below to estimate total (wet plus dry) deposition of S from SO₂ and N from NO₂.

$$D_s \text{ or } D_n = (X)(V_d)(R)(DEP)(Fc)$$

where: D_s = sulfur deposition flux (kg/ha/yr)

D_n = nitrogen deposition flux (kg/ha/yr)

X = pollutant concentration (ug/m³)

V_d = deposition velocity of 0.005 m/sec for SO₂ or 0.05 m/sec for HNO₃ (ref. IWAQM Phase1)

R = Ratio of molecular weights of elements to convert from SO₂ to S and NO₂ to N (14/46 = .3 for NO₂; 32/64 = .5 for SO₂)

Molecular weight of H=1, N=14, O=16, S=32.

DEP = total deposition to dry deposition ratio (assume this equals 2.0 unless there is other info)

Fc = units conversion of ug/m³ x m/sec to kg/ha/yr (315.4)

Step 2: Computation of Alkalinity Change from Annual Deposition Flux

This calculation provides an estimate of total equivalents of acid deposition over a year that either fall directly into the lake, or are deposited in the catchment that flows into the lake. This screening model assumes that all the equivalents of acidity eventually reach the lake, where they titrate the alkalinity.

Equation: % ANC change = [Hdep/ANC(o)] x 100

where:

ANC(o) = baseline ANC for entire lake catchment in eq = $W \times P \times (1-Et) \times A \times (10,000\text{m}^2/\text{ha}) \times (\text{eq}/10^6 \text{ ueq}) \times (10^3 \text{ liters}/\text{m}^3)$

A = baseline lake sample alkalinity in ueq/l

Hdep = acid deposition in eq = $[H(s) + H(n)] \times W \times 10,000\text{m}^2/\text{ha}$

Hs = sulfur deposition in eq/m²/yr = $Ds (\text{kg}/\text{ha}/\text{yr}) \times (\text{ha}/10,000\text{m}^2) \times (1000\text{g}/\text{kg}) \times (\text{eq}/16\text{g S})$

Hn = nitrogen deposition in eq/m²/yr = $Dn (\text{kg}/\text{ha}/\text{yr}) \times (\text{ha}/10,000\text{m}^2) \times (1000\text{g}/\text{kg}) \times (\text{eq}/14\text{g N})$

W = watershed area in ha

P = average annual precipitation in meters

Et = fraction of the annual precipitation lost to evaporation and transpiration (assume Et = .33 unless better info available)

Ds = sulfur deposition in kg/ha/yr from all sulfur species

Dn = nitrogen deposition in kg/ha/yr from all nitrogen species

Example

Wilderness Name: Sangre de Cristo Wilderness

Lake Name : Lower Stout Lake

Lake Location: UTM coordinates 4,245,150 N and 422,300 E

Input Data:

A (baseline ANC)	= 165 ueq/l
Ds (sulfur deposition)	= 0.023 kg/ha/yr
Dn (nitrogen deposition)	= 0.112 kg/ha/yr
W (watershed area)	= 16 hectares
P (precipitation)	= 1.1 meters

Intermediate Values:

ANC(o)	= 19,457 eq
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Hs	= 0.000144 eq/m ²
Hn	= 0.0008 eq/m ²
H(dep)	= 151.04 eq

% ANC change = $[151.04/19,457)] \times 100$
 = 0.78% change in Lower Stout Lake ANC projected from source specific sulfur and nitrogen deposition

References

Clayton, James. Alkalinity Generation in Snowmelt and Rain Runoff During Short Distance Flow Over Rock. Research Paper RMRS-RP-12. Ogden, UT; U.S. Department of Agriculture, Rocky Mountain Research Station. 1998.

Clayton, James. Research Soil Scientist and Watershed Team Leader of the Aquatics/Watershed Research Work Unit, USDA Forest Service- Rocky Mountain Research Station. Personal communication, August 1999.

Fox, Doug. "A Suggested Methodology for an Acid Deposition Screening Technique Applicable Within 200 km of Isolated Sources" Preliminary Draft, 1983.

Sullivan, T.J. and B.J. Cosby. Testing, Improvement and Confirmation of a Watershed Model of Acid-Base Chemistry. Water, Air and Soil Pollution 85:2607-2612. 1995.

Turk, John. Water Dipper Inc., formerly USGS Biogeochemistry Research Scientist. Personal communication, August-September 1999.

U.S. EPA Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts. EPA-454/R-98-019. December 1998

U.S. EPA Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 1 Report: Interim Recommendations for Modeling Long Range Transport and Impacts on Regional Visibility. EPA-454/R-93-015. April 1993.



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